Recent estimates suggest that 3.8 million sports- and recreation-related concussions occur annually in the United States [1]. “Concussion,” often used interchangeably with mild traumatic brain injury (MTBI), represents a serious public health threat and has become an increasingly hot research topic. Without loss of consciousness, MTBI can be difficult to diagnose, as it commonly presents a complex and variable symptomatology. Misdiagnosis can carry severe repercussions if it results in erroneous return-to-play decisions for athletes, since secondary impacts can lead to severe complications. Furthermore, initial concussions are consistently linked to increased risk for subsequent concussions, likely due to residual cognitive deficits. Consequently, many researchers are attempting to develop non-invasive neuroimaging methods, such as quantitative electroencephalogram (qEEG), for identifying concussions objectively and accurately.

Cheng Cao and colleagues at Pennsylvania State University were recently the first to use qEEG and the support vector machine (SVM) pattern classifier to identify college athletes who had suffered a concussion 30-days prior [2]. qEEG refers to a set of numerical methods used for EEG analysis, including Fourier decomposition into a voltage by frequency spectral graph, and wavelet analysis. SVM is a pattern classifier which constructs a hyperplane in high-dimensional feature-space that best separates groups of interest in the data (where features are variables that can help discriminate groups or classes of interest).

The researchers recruited 61 healthy collegiate athletes without a history of concussion, and 30 of these suffered a concussion over the course of the study. EEG recordings were taken from 19 recording electrodes, both at baseline and 30-days post-concussion, in three different postural positions with eyes closed (sitting, standing, or standing on foam). This paradigm was used because postural and balance deficits are common post-concussive features used in clinical assessment. They calculated power in 35 frequency bands, for each electrode, and in each postural trial, yielding 1,995 total possible features.

The researchers used multiple feature selection methods to narrow this set down to only 10 features of interest. With these, SVM correctly classified 77.1% of the subjects as MTBI or healthy control, with 96.7% sensitivity (probability of identification given MTBI), and 69.1% selectivity (probability of MTBI given identification). The most important features were from recording sites in occipital (O2) and temporal areas (T3, T4, T5, & T6), and half were from the standing on foam postural position. These were areas also implicated in previous studies, and the postural results were congruent with expectations that more difficult postural tasks would elicit greater deficits.

While even greater accuracy and selectivity will likely be achieved in the near future, these results represent a substantial achievement. By 30 days post-injury, the concussed athletes had been cleared for sport participation, and all clinical symptoms had subsided. The fact that EEG features were still able to distinguish previously concussed athletes from healthy controls suggests that EEG may provide subtle indicators of sustained functional impairments that persist long after behavior and other measures appear normal. Determining the clinical relevance of these methods represents an important task for future research.

References